[CONTRIBUTION FROM THE EASTERN REGIONAL RESEARCH LABORATORY[1]]

Fatty Acid Amides. I. Preparation of Amides of Oleic and the 9,10-Dihydroxystearic Acids[1a]

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Amides of long-chain fatty acids have numerous actual and potential uses, and many publications have appeared describing their preparation and properties. Unfortunately, a large proportion of this work is incomplete and, in some cases, unreliable, and this is especially true of the amides of unsaturated fatty acids. Furthermore, the information available is not sufficient to permit the selection of the best method for preparing various types of N-substituted amides of long-chain acids. In this paper, the first of a series, we are describing the results of our study of the preparation of oleamide and N-substituted amides of oleic acid in which the substituent group is aryl, acetyl, 2-hydroxyethyl, or *n*-alkyl (from one to eighteen carbon atoms). Some amides of the 9,10-dihydroxystearic acids[2] were also prepared and are described here.

A few of the compounds which we prepared had already been reported in the literature,[3] but, in general, the earlier investigators employed impure starting materials, and the final products were incompletely characterized. The probability that most of these earlier products were impure is indicated by the fact that the melting points which we obtained were usually higher than those reported in the literature for the same compound. It soon became evident, however, that sharpness or constancy of melting point alone is an unsatisfactory criterion of purity, because related impurities, such as homologous or autoxidized amides, could be present without causing an appreciable depression of the melting point. All the amides reported in this paper were prepared from carefully purified starting materials. All reactions and drying operations were conducted in an atmosphere of nitrogen. The purity of the amides was checked, when possible, by determination of iodine number, per cent. hydroxyl, and carbon, hydrogen and nitrogen content. By operating in this way, the once-crystallized amides were generally more than 95% pure, and in some cases they were of analytical purity.

The preparative method employed varied with the boiling point of the amine. With aqueous amine solutions or low-boiling amines, the amides were prepared by reaction of the amine with the acid chloride at atmospheric pressure and at or below room temperature, or by reaction of the amine with an ester under pressure at elevated temperatures. With high-boiling amines, reaction between the amine and fatty acid or ester at elevated temperatures resulted in high yields of amides. Oleamide was prepared by the reaction of oleyl chloride with aqueous ammonia at atmospheric pressure, by the reaction of methyl oleate with aqueous or liquid ammonia under pressure at elevated temperatures, and by the reaction of oleic acid with formamide, acetamide, urea or acetylurea. The best laboratory method for the preparation of oleamide consists in the reaction of oleyl chloride with aqueous ammonia, but if high-pressure equipment is available, the reaction of methyl oleate with liquid ammonia is somewhat more convenient to carry out, and isolation of the product offers fewer problems. The reaction of oleic acid with formamide, urea or acetylurea gave fair yields of oleamide, and these reactions were reasonably satisfactory laboratory procedures. In the reaction of oleic acid with acetamide, pure oleamide could not be isolated, and study of this method was discontinued. The reaction of fatty acids with urea has been reported by previous investigators.[4,5,6] No references to the reaction of acids with other amides of low molecular weight could be found.

In the preparation of N-(2-hydroxyethyl) amides, prolonged heating of the fatty acids at high temperatures with stoichiometric quantities or with less than 25% molar excess of ethanolamine yielded undesirable by-products, which we were unable to separate. By employing a 50% molar excess of ethanolamine, good yields of amide were obtained in a relatively short time. The N-aryl amides were generally more difficult to prepare than the N-alkyl amides. Excess arylamine must be avoided, because it causes the formation of colored products, which are difficult to remove, and it results in no increase in yield.

Experimental

The distillation of amines and the preparation and drying of the amides were carried out in an atmosphere of nitrogen.

Starting Materials.—Oleic acid (98%) and methyl oleate (99%) were prepared from olive oil fatty acids by fractional distillation and low-temperature crystallization.[7] The amines were obtained from various commercial sources

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[1] One of the laboratories of the Bureau of Agricultural and Industrial Chemistry, Agricultural Research Administration, U. S. Department of Agriculture. Article not copyrighted.

[1a] Presented at the Meeting in Miniature of the Philadelphia Section of the American Chemical Society, Jan. 20, 1949.

[2] Swern, Billen, Findley and Scanlan, THIS JOURNAL, **67**, 1786 (1945).

[3] Aschan, *Ber.*, **31**, 2344 (1898); De'Conno, *Gazz. chim. ital.*, **47**, I, 93 (1917); Harber, *Iowa State Coll. J. Sci.*, **15**, 13 (1940); Olson, *Die Chemie*, **56**, 202 (1943).

[4] Cherbuliez and Landolt, *Helv. Chim. Acta*, **29**, 1438 (1946).

[5] D'Alelio and Reid, U. S. Patent 2,109,941 (1938).

[6] Bruson, U. S. Patent 1,989,968 (1935).

[7] Brown and Shinowara, THIS JOURNAL, **59**, 6 (1937); Wheeler and Riemenschneider, *Oil and Soap*, **16**, 207 (1939); Swern, Knight and Findley, *ibid.*, **21**, 133 (1944).

TABLE I

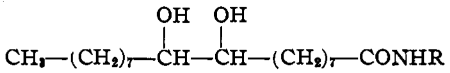
CHARACTERISTICS OF N-SUBSTITUTED OLEAMIDES $CH_3—(CH_2)_7—CH═CH—(CH_2)_7—CONHR$

R	Method	Purification[a]	Once crystallized: Yield, %	Once crystallized: M. p., °C.	Recrystallized[b]: Yield, %	M. p., °C.	Carbon, % Calcd.	Carbon, % Found	Hydrogen, % Calcd.	Hydrogen, % Found	Nitrogen, % Calcd.	Nitrogen, % Found	Iodine no.[c] Calcd.	Iodine no.[c] Found
Methyl	H	S, 5/1, −20	95[d]	34.0–35.0	70	34.5–35.0	77.2	77.1	12.6	12.7	4.74	4.56	85.9	84.8
Ethyl	H	S, 5/1, −10	91	34.0–34.5	89	34.5–35.0	77.6	77.0	12.7	12.5	4.53	4.39	82.0	81.9
n-Propyl	I	S, 7/1, −10	88	32.0	85	32.0	78.0	77.6	12.8	12.7	4.33	4.24	78.5	78.8
n-Butyl	I	S, 5/1, −15	88	28.5–29.0	83	29.5–30.0	78.3	77.8	12.8	12.6	4.15	4.07	75.2	74.0
n-Amyl	J	S, 5/1, −20	68	29.0–30.0	60	30.0–30.5	78.6	78.7	12.9	13.0	3.98	4.09	72.2	72.3
n-Hexyl	J	S, 5/1, −20	81[e]	31.0	68	31.0–31.5	78.9	78.8	13.0	13.2	3.83	3.75	69.4	69.3
n-Octyl	K	E, 7/1, 0	84	....	65	39.5–40.5	79.3	79.2	13.1	12.8	3.56	3.37	64.5	64.3
n-Decyl	J	E, 4/1, 0	87[f]	45.4–46.0	68	46.0	79.8	79.6	13.2	13.2	3.32	3.10	60.2	60.1
n-Dodecyl	J	E, 10/1, 0	93[g]	53.0–54.0	86	53.5–54.0	80.1	79.8	13.2	12.9	3.11	3.07	56.4	56.1
n-Tetradecyl	J	E, 10/1, 20	90	....	83	60.0–61.0	80.4	80.3	13.3	13.4	2.93	2.84	53.1	52.5
n-Hexadecyl	J	E, 10/1, 25	92	64.5–65.0	87	65.5–66.0	80.7	80.5	13.4	13.6	2.77	2.70	50.2	49.1
n-Octadecyl	J	E, 10/1, 25	91[h]	68.5–69.0	89	70.0	81.0	81.1	13.4	13.4	2.62	2.45	47.5	47.5
Phenyl	L	S, 5/1, 0	82	43.0–43.5	73	45.5–46.0	80.6	80.9	11.0	10.9	3.92	3.89	71.0	..[k]
o-Tolyl	L	S, 7/1, −20	77	.......[i]	58	44.0–44.5	80.8	80.8	11.1	11.1	3.77	3.71	68.1	..[k]
α-Naphthyl	L	A, 4/1, 0	79	.......[j]	34	61.5–62.0	82.5	82.8	10.1	10.3	3.44	3.49	62.3	..[k]
β-Naphthyl	L	A, 3/1, 0	70	68.5–69.0	44	73.5–74.0	82.5	82.5	10.1	9.9	3.44	3.66	62.3	..[k]
Acetyl	M	S, 3/1, −20	27	48.0–49.0	23	51.5–52.0	74.3	74.4	11.5	11.2	4.33	4.34	78.5	78.2
2-Hydroxyethyl	N	S, 8/1, 0	95	....	81	63.0–64.0	73.8	74.4	12.1	12.1	4.31	4.38	78.0	78.0

[a] The first letter indicates solvent (S = petroleum naphtha, boiling range 63-70°, E = 95% ethanol, A = acetone). The numbers indicate solvent ratio in ml./g., and crystallization temperature in degrees C. [b] Recrystallized one or more times from the same solvent with the following exceptions: N-hexyloleamide, once from ethyl ether, 2 ml./g. at 0°; N-(*o*-tolyl)-oleamide once from the same solvent and once from acetone 3 ml./g. at 0°; N-(α-naphthyl)-oleamide, twice from acetone, 7 ml./g. at 0° and once from 95% ethanol, 5 ml./g. at 0°; and N-acetyloleamide, once from acetone 5 ml./g. at −20°. [c] One-half hour Wijs method. [d] A yield of 45% was obtained by method B, employing 25% aqueous methylamine. [e] A yield of 47% was obtained by method K. [f] 66% by method K. [g] 75% by method K. [h] 88% by method K. [i] M. p. 2nd. crystn. 43.5–44.0°; yield 74%. [j] M. p. 2nd. crystn. 57.0-57.5°; yield 68%. [k] The iodine number was higher than the theoretical value, usually by six to eight units, depending on the size of the sample. N-Phenylstearamide had an iodine number of from six to eight units. This is caused by addition of halogen to the aromatic ring.

TABLE II

CHARACTERISTICS OF N-SUBSTITUTED AMIDES OF THE 9,10-DIHYDROXYSTEARIC ACIDS,



$$CH_3—(CH_2)_7—\overset{\displaystyle OH}{\overset{|}{C}H}—\overset{\displaystyle OH}{\overset{|}{C}H}—(CH_2)_7—CONHR$$

R	Method	Purification[a]	Once crystallized: Yield, %	Once crystallized: M. p., °C.	Recrystallized: Yield, %	M. p., °C.	Carbon, % Calcd.	Carbon, % Found	Hydrogen, % Calcd.	Hydrogen, % Found	Nitrogen, % Calcd.	Nitrogen, % Found	Hydroxyl, %[b] Calcd.	Hydroxyl, %[b] Found
Amides from Low Melting Acid (m. p. 95°)														
n-Amyl	J	A, 20/1, 0	71	100.0–100.5	62[c]	101.0	71.6	71.8	12.3	12.3	3.63	3.77	8.8	8.9
n-Decyl	J	E, 8/1, 0	86	106.0–106.5	77[d]	106.5–107.0	73.8	73.9	12.6	12.6	3.07	3.22	7.5	7.5
n-Octadecyl	J	E, 26/1, 0	85	104.0–105.0	77[d]	107.5–108.0	76.1	76.2	13.0	13.2	2.47	2.43	6.0	6.0
2-Hydroxyethyl	N	E, 12/1, 0	68	110.0–110.5	55[e]	110.5–111.0	66.8	66.8	11.5	11.3	3.90	3.85	14.2	14.2
Amides from High Melting Acid (m. p. 130°)														
n-Amyl	J	E, 14/1, 25	56	140.0–140.5	44[f]	140.5	71.6	71.7	12.3	12.1	3.63	3.67	8.8	8.8
n-Decyl	J	E, 36/1, 25	69	140.0–140.5	55[g]	140.5	73.8	73.8	12.6	12.3	3.07	2.98	7.5	7.5
n-Octadecyl	J	B, 30/1, 25	83	138.5–139.0	76[h]	139.5–140.0	76.1	75.8	13.0	13.0	2.47	2.57	6.0	6.0
2-Hydroxyethyl	N	E, 18/1, 0	70	146.5–147.0	68[h]	152.0	66.8	66.8	11.5	11.4	3.90	3.80	14.2	14.2

[a] The first letter indicates solvent (A = acetone, E = 95% ethanol, B = butanol). The numbers indicate solvent ratio in ml./g., and crystallization temperature in degrees. [b] Determined by the method of Ogg, Porter and Willits, *Ind. Eng. Chem., Anal. Ed.*, **17**, 394 (1945). [c] Recrystallized three times from 95% ethanol (10 ml./g.) at 0°. [d] Recrystallized three times at 0°. [e] Recrystallized twice from 95% ethanol (5 ml./g.) at 0°. [f] Recrystallized twice from 95% ethanol at 0°. [g] Recrystallized twice from butanol (10 ml./g.) at 25°. [h] Recrystallized from 95% ethanol (6 ml./g.) at 0°.

and were purified by fractional distillation through packed columns. The amine fractions having the correct physical and chemical constants were used. Aqueous solutions of methyl and ethyl amine were used without further purification.

Preparation of Oleamide

Method A. Reaction of Oleyl Chloride with Aqueous Ammonia.—To 300 ml. of well-stirred, ice cold, concentrated ammonium hydroxide (29% NH_3), 60.0 g. (0.2 mole) of undistilled oleyl chloride[8] was added dropwise. The resulting emulsion of oleamide, ammonium oleate and aqueous ammonium hydroxide was extracted with petroleum naphtha, boiling range 63-70°, in a liquid-liquid extractor. The solvent layer, which contained a small quantity of suspended by-product, was treated with 1 g. of activated carbon and filtered. Additional petroleum naphtha was added to bring the solvent-solute ratio up to 7 ml./g., and the solution was cooled to 17°. The yield of oleamide was 51 g. (90%), m. p. 75.5-76.0°. Recrystallization from ethanol (7 ml./g.) yielded 44.5 g. (79%), m. p. 76.0°. *Anal.* Calcd. for $C_{18}H_{35}ON$: iodine number, 90.2; C, 76.8; H, 12.5; N, 4.97. Found: iodine number, 90.2; C, 77.0; H, 12.4; N, 4.91.

Method B. Reaction of Methyl Oleate with Aqueous Ammonia.—Fifty-nine grams (0.2 mole) of methyl oleate and 123 g. of aqueous ammonium hydroxide (27.6% NH_3, by weight) were heated at 175° for six hours in a specially constructed steel bomb (400-ml. capacity), which was rotated end over end in a thermostatically controlled oil bath.[9] After the bomb had cooled, the contents were transferred to a beaker and agitated while being warmed

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[8] Bauer, *Oil and Soap*, **23**, 1 (1946).

[9] Phillips, *Ind. Eng. Chem.*, **17**, 721 (1925).

on the steam-bath to expel the ammonia. The mixture was then acidified with 6 *N* hydrochloric acid, and the melted oleamide layer was washed with warm water until free of acid. It was then dissolved in petroleum naphtha (3 ml./g.), treated with activated carbon (1.2 g.) and filtered. The filtrate was adjusted to 5 ml. of solvent per g. of solute and cooled to 0°, yielding 27.8 g. (49%) of oleamide, m. p. 72.5-73.0°. Recrystallization from ethanol (5 ml./g.) yielded 23.8 g. (42%), m. p. 76.0°. *Anal.* Calcd. for oleamide $C_{18}H_{35}ON$: iodine number, 90.2. Found: iodine number, 90.1.

Method C. Reaction of Methyl Oleate with Liquid Ammonia.—Thirty grams of methyl oleate (0.1 mole) was placed in a steel bomb (400 ml. capacity) and cooled to −45°. Thirty ml. of liquid ammonia was drawn off[10] into a graduated cylinder packed in solid carbon dioxide and added to the cold methyl oleate. The lid of the bomb was quickly put in place and screwed down. The bomb was rotated end over end for six hours between 165 and 180° in a thermostatically controlled oil-bath,[9] after which it was removed and cooled to room temperature. By means of a needle valve, the excess ammonia was allowed to escape before the bomb was opened. The white granular solid obtained was dissolved in petroleum naphtha (5 ml./g.) and treated with 2% of activated carbon. Additional warm solvent was used to aid in transferring and washing, and the final volume of solvent to solute was 7 ml./g. The solution was cooled to 0° and filtered, yielding 24.7 g. (88%) of oleamide, m. p. 72.5-73.0°. Recrystallization from ethanol (5 ml./g.) yielded 21.2 g. (75%), m. p. 76.0°. Analysis: Calcd. for oleamide $C_{18}H_{35}ON$: iodine number, 90.2. Found: iodine number, 90.1.

Method D. Reaction of Oleic Acid with Formamide.—A mixture of 28.3 g. (0.10 mole) of oleic acid and 5.4 g. (0.12 mole) of formamide was heated in a 200-ml. 3-neck flask provided with a thermometer, an upright steam-heated condenser and a gas inlet tube. The temperature was raised to 185° in about one-half hour, but another hour was required to reach 230°. The reaction mixture was then maintained at 230° for an additional half hour. The dark-brown reaction mixture, which began to solidify at 56°, was dissolved in 65 ml. of acetone, treated with 0.6 g. of activated carbon for one-half hour and filtered. Sufficient acetone was added to the filtrate to increase the solvent-solute ratio to 3 ml./g., and the solution was cooled to 0°. The copious white crystalline precipitate, 16.7 g. (59%), consisting substantially of oleamide, m. p. 72.0-72.5°, was recrystallized from acetone (3 ml./g.) yielding 14.0 g. (50%) of pure oleamide, m. p. 75.0-75.5°. *Anal.* Calcd. for $C_{18}H_{35}ON$: iodine number, 90.2; C, 76.8; H, 12.5; N 4.97. Found: iodine number, 90.0; C, 77.1; H, 12.4; N, 4.79.

Method E. Reaction of Oleic Acid with Acetylurea.—A mixture of 28.3 g. (0.1 mole) of oleic acid and 10.3 g. (0.1 mole) of acetylurea was heated together in a 200-ml. three-neck flask provided with a thermometer, air condenser and gas inlet tube. The temperature was raised to 230° in forty minutes, and an attempt was made to maintain it at this point for five hours; however, the temperature gradually decreased to 215° during this time. To the cooled reaction mixture was added 32 ml. of hot acetone, and the insoluble portion was filtered off and washed with 32 ml. of hot solvent. The solution was treated with 0.6 g. of activated carbon and filtered, and the filtrate was adjusted to 3 ml. of solvent per g. of solute. The solution was cooled to 0°, yielding 16.0 g. (57%) of crude oleamide, m. p. 69.0-71.0°. Recrystallization from ethanol (7 ml./g.) yielded 11.6 g. (41%), m. p. 76.0°. *Anal.* Calcd. for oleamide $C_{18}H_{35}ON$: iodine number, 90.2; C, 76.8; H, 12.5; N, 4.97. Found: iodine number, 89.3; C, 77.1; H, 12.5; N, 4.83.

Method F. Reaction of Oleic Acid with Urea.—A mixture of 28.3 g. (0.1 mole) of oleic acid and 18.0 g. (0.3 mole) of urea was heated as quickly as possible[4] to 230° and then maintained at this temperature for two hours. The oleamide was extracted by washing with petroleum naphtha. The extract was washed with warm water, treated with 0.6 g. of activated carbon and filtered. Sufficient solvent was added to the filtrate to bring the solvent-solute ratio to 7 ml./g., and the solution was cooled to 0°, yielding 13.6 g. (48%) of oleamide, m. p. 73.0-74.0°. Two additional crystallizations from ethanol (7 ml./g.) yielded 9.6 g. (34%), m. p. 75.0-75.5°. *Anal.* Calcd. for $C_{18}H_{35}ON$: iodine number, 90.2; C, 76.8; H, 12.5; N, 4.97. Found: iodine number, 90.0; C, 76.3; H, 12.4; N, 5.11.

Method G. Reaction of Oleic Acid with Acetamide.—Twenty-eight and three-tenths grams (0.1 mole) of oleic acid and 8.9 g. (0.15 mole) of acetamide were heated for two hours at 225-240° in a 500-ml. three-neck flask, provided with a thermometer, a short distilling adapter and a gas inlet tube. During this time 1.6 g. of acetic acid distilled over. The cooled reaction mixture was dissolved in petroleum naphtha and washed with hot water. The solution was then dried over sodium sulfate, treated with 0.6 g. of activated carbon and filtered, and additional solvent was added to the filtrate to bring the solvent-solute ratio to 7 ml./g. The solution was cooled to 0°, yielding 12.0 g. (42.6%) of white crystalline precipitate; m. p. 72.5-74.0°. *Anal.* Calcd. for oleamide $C_{18}H_{35}ON$: iodine number, 90.2; C, 76.8; H, 12.5; N, 4.97. Found: iodine number, 82.6; C, 76.3; H, 12.5; N, 4.97. Recrystallization from petroleum naphtha (7 ml./g.) and twice from 95% ethanol (7 ml./g.) gave a 19% over-all yield (calculated as oleamide), m. p. 81.0-81.5°; iodine number, 81.0; C, 76.7; H, 12.5; N, 4.94. The product was not identified.

Preparation of N-Alkyl Oleamides

Method H. Reaction of Oleyl Chloride with Aqueous Amines.—Sixty grams (0.2 mole) of undistilled oleyl chloride[8] was added dropwise with stirring to 273 g. (2.2 moles) of ice cold 25% aqueous methylamine. The mixture was warmed to about 40° to melt the N-methyloleamide, the aqueous layer was discarded, and the yellow oily layer was dissolved in warm petroleum naphtha and then washed successively with dilute hydrochloric acid and water until acid free. The upper layer containing the crude N-methyloleamide was dried with sodium sulfate and then heated with 2% of activated carbon and filtered. The volume of solution was adjusted to a ratio of about five ml. of solvent per g. of solute, and the solution was then cooled to −20°. The yield of N-methyloleamide was 57 g. (95%), m. p. 34.0-35.0°. Two recrystallizations from petroleum naphtha (5 ml./g.) yielded 42 g. (70%) of pure N-methyloleamide; m. p. 34.5-35.0° (Table I).

Method I. Reaction of Oleyl Chloride with Low-boiling Amines.—The preparation of N-(*n*-butyl)-oleamide is typical. Sixty grams (0.2 mole) of undistilled oleyl chloride[8] was added slowly to a well-stirred solution of 29 g. (0.4 mole) of *n*-butylamine in 340 ml. of petroleum naphtha. In some cases the solution was cooled in an ice-bath during the addition of oleyl chloride. After the addition was complete, 150 ml. of 1 *N* HCl was added, and the mixture well stirred. The mixture was allowed to separate, and the upper layer containing the amide was washed until acid free. It was then treated with 1.4 g. of activated carbon, additional solvent was added to give 5 ml. of solvent per g., and the solution was cooled to −15°. The yield of N-(*n*-butyl)-oleamide was 59 g. (88%), m. p. 28.5-29.0°. Two recrystallizations from petroleum naphtha (5 ml./g.) yielded 56 g. (83%) of pure N-(*n*-butyl)-oleamide, m. p. 29.5-30.0° (Table I).

Method J. Reaction of Oleic and 9,10-Dihydroxystearic Acids with High-boiling Alkyl Amines.—This method, the simplest preparative method, can be readily employed when the amine is not too volatile. The preparation of N-(*n*-dodecyl)-oleamide is typical. Fifty-six and five-tenths grams (0.2 mole) of oleic acid and 37.4 g. (0.2 mole) of *n*-dodecylamine were weighed into a three-neck flask, fitted with a West condenser in an upright po-

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[10] E. C. Franklin, "The Nitrogen System of Compounds," (A. C. S. Monograph No. 68) Appendix, Reinhold Publishing Corp., New York, N. Y., 1935; Johnson and Fernelius, *J. Chem. Education*, 6, 441 (1929).

sition. The apparatus was flushed out with nitrogen and then the flow of nitrogen was reduced to the lowest possible rate to exclude air but not to drive off the amine. The mixture was heated rapidly to 230° and maintained at this temperature for 35 minutes. At the point at which water began to be evolved, steam was passed down through the water jacket of the condenser to help expel the water vapor. The pale yellow crude amide began to solidify at 54°. It was dissolved in about 700 ml. of 95% ethanol, treated with 1.8 g. of activated carbon and filtered hot. The solvent–solute ratio of the filtrate was adjusted to 10 ml. of solvent per g. of solute, and the solution was cooled to 0°, yielding 84 g. (93%) of N-(*n*-dodecyl)-oleamide, m. p. 53.0–54.0°. Two recrystallizations from 95% ethanol (10 ml./g.) yielded 77 g. (86%) of pure N-(*n*-dodecyl)-oleamide, m. p. 53.5–54.0° (Table I).

Method K. Reaction of Methyl Oleate with High Boiling Amines.—This method was essentially the same as Method J, except that the reactants were heated for three hours at 230° to complete the amidation. The yield of N-(*n*-dodecyl)-oleamide prepared in this manner was 69%.

Preparation of N-Aryl Amides

Method L. Reaction of Oleic Acid with Aromatic Amines.—The preparation of N-phenyloleamide is typical. One hundred and fifty-five grams (0.55 mole) of oleic acid and 52 g. (0.55 mole) of freshly distilled aniline were weighed into a 3-neck flask. The apparatus and procedure were the same as those described in Method J except that it was necessary to maintain the reactants at 230° for five hours to obtain the maximum yield of N-phenyloleamide. The pale-yellow solution began to solidify at 34°. The yield of crude product was 196 g. (99.7%). On crystallization from petroleum naphtha (5 ml./g.) at 0°, 160 g. (82%) of N-phenyloleamide, m. p. 43.0–43.5°, was obtained. Three recrystallizations from petroleum naphtha (10 ml./g.), including treatment with 1% of activated carbon, yielded 144 g. (73%) of N-phenyloleamide as lustrous crystalline flakes, m. p. 45.5–46.0° (Table I).

Preparation of N-Acetyloleamide

Method M. Reaction of Oleamide with Acetic Anhydride.—A mixture of 14.2 g. (0.05 mole) of oleamide and 28.4 g. (0.28 mole) of acetic anhydride was refluxed for four hours. The excess acetic anhydride was distilled off, and the remaining light yellow oil was taken up in an equal volume of petroleum naphtha and washed with warm water until acid free. After being dried with sodium sulfate, the solution was treated with 0.3 g. of activated carbon and filtered. The solvent-solute ratio of the filtrate was increased to 3 ml./g., and the solution was cooled to −20°, yielding 4.4 g. (27%) of crude N-acetyloleamide as a white crystalline solid, m. p. 48–49°. Two recrystallizations from acetone (5 ml./g.) yielded 3.2 g. (23%) of pure N-acetyloleamide, m. p. 51.5–52.0° (Table I).

Preparation of N-(2-Hydroxyethyl)-amides

Method N. Reaction of Oleic Acid with Ethanolamine.—A mixture of 56.5 g. (0.2 mole) of oleic acid and 18.4 g. (0.3 mole) of ethanolamine was refluxed for two hours. The temperature gradually dropped from 180 to 155°. The reaction mixture, which began to solidify at 54°, was dissolved in 325 ml. of petroleum naphtha, treated with 1.3 g. of activated carbon for one-half hour, and filtered. The solvent-solute ratio was increased to 8 ml./g., and the solution was cooled to 0°, yielding 62 g. (95%) of N-(2-hydroxyethyl)-oleamide. Since the amide still contained ethanolamine, no attempt was made to determine its melting point, and it was recrystallized from petroleum naphtha, yielding 52.7 g. (81%) of pure N-(2-hydroxyethyl)-oleamide, m. p. 63.0–64.0° (Table I).

N-(2-Hydroxyethyl)-9,10-dihydroxystearamides.—The amides were prepared from the two 9,10-dihydroxystearic acids, m. p. 95 and 130°, by refluxing for fifteen minutes with a 50% excess of ethanolamine. The crude amides were crystallized from 95% ethanol, 12 ml./g. and 18 ml./g., respectively. The results are shown in Table II.

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Summary

Methods of preparation of oleamide and N-(*n*-alkyl)-oleamides from methyl through hexyl and the even members from octyl through octadecyl have been studied, and the amides have been obtained in good yield. N-(2-Hydroxyethyl)-oleamide, N-acetyloleamide, and several representative N-aryloleamides and N-alkyl-9,10-dihydroxystearamides also have been prepared. Most of these amides have not been previously recorded in the literature; with few exceptions the others are purer than the corresponding products previously reported.

No reference to the preparation of oleamide by the reaction of oleic acid with formamide or acetylurea could be found in the literature. In these reactions, fair yields of oleamide were obtained by relatively simple procedures, and these methods should be generally suitable for the preparation of the unsubstituted amides of other carboxylic acids.

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